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The Differential Reaction of Strains Within a Variety of Wheat to Physiologic Forms of Puccinia Graminis Tritici

T. A. KIESSELBACH AND GEORGE L. PELTIER
DEPARTMENTS OF AGRONOMY AND PLANT PATHOLOGY

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INTRODUCTION

Black stem rust of wheat *(Puccinia graminis tritici* (Pers.) Erikss. & Henn.), which occurs in Nebraska and thruout most of the wheat producing regions of the world, is of a composite nature, in that it consists of a number of physiologic forms which can be determined by their action on different varieties of *Triticum* species, as shown by Stakman and Levine.[1] The ordinary commercial variety of wheat may likewise be regarded as a mixture, in that it consists of numerous strains, which differ in some more or less important characteristics, as has been frequently indicated in the literature concerning wheat improvement.

The object of this investigation has been to analyze such a commercial mass-variety of wheat from the standpoint of the differential reaction of its component strains to a number of the physiologic forms of *Puccinia graminis tritici* found in Nebraska. The applied significance of such a study would be the discovery of productive wheat strains in a commercial variety, which are resistant to a relatively large number of prevalent physiologic forms, thereby reducing the likelihood of severe rust damage from season to season, as it has been determined (unpublished data) from epidemiological studies in Nebraska that the physiologic forms which occur in the field may vary in number, identity, distribution, and intensity in different seasons.

DESCRIPTION OF THE WHEAT VARIETY

The variety used in this test is known as Crimean C. I. 1435. This is an importation of common hard red winter wheat made in 1900 by the United States Department of Agriculture from Ambracievka, Don Territory, Russia. According to J. A. Clark [2] the source of this wheat is somewhat different from the source of other Crimean, Kharkof,

[1] Stakman, E. C. and Levine, M. N., The Determination of Biologic Forms of Puccinia graminis on Triticum spp. Minn. Agr. Exp. Sta. Tech. Bul. 8. 10 p. fig. 1. 1922.

[2] Personal letter.

and Turkey introductions obtained about the same time. Seed was secured by the Nebraska Agricultural Experiment Station thru the Office of Cereal Crops and Diseases in 1914. In succeeding tests Crimean C. I. 1435 has proved to be an unusually productive mass-variety. Compared during a 7-year period with ordinary Turkey winter wheat which has been grown for many years at this Station, and with Kanred, which is a relatively rust resistant selection made by the Kansas Agricultural Experiment Station from this same Crimean C. I. 1435, we have the results reported in Table 1.

TABLE 1.—*Comparative performance of Crimean C. I. 1435, Commercial Turkey, and Kanred grown in the wheat nursery*[1] *during 7 years, 1915-1922*

Yield and plant characteristics	Years duration of test	Turkey	Crimean C. I. 1435	Kanred
Yield grain per acre[2] (*bushels*)	7	30.3	33.6	36.2
Relative yield grain per acre (*per cent*)	7	100.0	110.9	119.5
Protein in grain (*per cent*)	6	15.1	15.7	15.1
Yield straw per care (*tons*)	7	2.4	2.4	2.4
Plant height (*inches*)	7	38.0	39.0	37.0
Lodging (*per cent*)	7	18.0	14.0	23.0
Date in head	7	6/3	6/2	6/2
Date ripe	7	7/2	7/2	7/1
Black stem rust[3] in 1920 (*per cent*)		49.0	43.0	19.0
Milling and baking[4] tests, 3 yr. av., 1921-1923				
Weight of grain per bushel (*lbs.*)	3	58.0	57.5	59.0
Crude protein in grain (*per cent*)	3	14.2	15.4	14.3
Ash in flour (*per cent*)	3	.45	.45	.43
Straight flour (*per cent*)	3	63.8	63.3	64.9
Water used in dough (*per cent*)	3	63.0	66.0	65.0
Loaf volume (*c. c.*)	3	1870	1890	1775
Loaf weight (*grams*)	3	480	479	485
Bread color (*per cent*)	3	97	98	98
Bread texture (*per cent*)	3	94	95	94

[1]Ten replications of 5-row nursery blocks each year.

[2]In a 3-year average triplicated field plat test, 1921-1923, Turkey, Crimean C. I. 1435, and Kanred yielded 30.5, 32.1, and 33.5 bu. per acre respectively. These are relative yields of 100, 105, and 110 per cent.

[3]Black stem rust recorded on basis of United States Department of Agriculture rust chart published in United States Department of Agriculture Bulletin 1046, by L. E. Melchers and J. H. Parker.

[4]The milling and baking tests were made under the direction of Dr. M. J. Blish, Station Chemist.

Because of its outstanding performance among commercial winter wheat varieties, Crimean C. I. 1435 was used as the basis of a selection nursery begun in 1921. A thousand spaced plants were grown and these served as foundation "mother plants." These were tested in plant rows in 1923 with the result that all except the 578 most promising strains were discarded. It is these 578 strains whose individual re-

action to the physiologic forms of rust is herewith reported.

Forty-three additional varieties and strains were tested for their rust reactions in conjunction with these Crimean strains during both seasons. Since many of these are extensively grown in various parts of this country, their reactions provide a valuable basis for appraising the relative rust resistance of these Crimean strains.

DESCRIPTION AND HISTORY OF THE PHYSIOLOGIC FORMS OF PUCCINIA GRAMINIS TRITICI

The physiologic forms of rust used included p. f. 6, 14, 21, 29, 3, 10, 12, 18, 25, and 32. With the exception of p. f. 14 and 21, these physiologic forms were isolated from collections of stem rust made by Mr. A. F. Thiel, Associate Pathologist, in charge of Barberry Eradication in Nebraska, Office of Cereal Crops and Diseases, United States Department of Agriculture, and his assistants in various localities in Nebraska during the summer of 1924. Physiologic form 14 was identified from stem rust material collected at Sacaton, Ariz., while material of p. f. 21 was obtained from Dr. M. N. Levine, Associate Pathologist, Office of Cereal Crops and Diseases, United States Department of Agriculture, stationed at the Agricultural Experiment Station, St. Paul, Minnesota, in the fall of 1923. During the winter of 1924, p. f. 21 was identified from a number of stem rust collections made the previous summer in Nebraska. However, p. f. 14 has not yet been identified from any collections made in the state.

The reactions of these 10 physiologic forms on the 12 differential hosts as determined under control conditions in the Plant Pathology greenhouse, were essentially the same as those listed by Stakman and Levine.[1] In determining the identity of these physiologic forms, 30 plants of each differential host were used. Thus these physiologic forms were pure when used to infect the various wheat strains as judged by their reactions on the differential hosts (Table 2). It will be noted that Kanred is resistant to the four physiologic forms, 6, 14, 21, and 29, while it is susceptible to p. f. 3, 10, 12, 18, 25, and 32.

Since the infected plants were grown on an open bench, a recheck of each physiologic form was made after each set was read. When the rust material was not being used in the

[1] L. C.

greenhouse it was stored in humidity chambers held at a temperature of 5° C. and 50 per cent relative humidity. The physiologic forms were again rechecked each time they were built up from the material kept in cold storage. Physiologic forms 3, 10, 18, and 21 retained their purity on all rechecks both years, as judged by their reaction on the differential hosts. Thru an accident, p. f. 6 and 14 were lost during storage thru the summer of 1925.

TABLE 2.—*Comparative reactions of the 12 differntial hosts to 10 physiologic forms of Puccinia graminis tritici*

Physiologic forms	Variety and reaction[1]											
	Little Club C. I. 4066	Marquis C. I. 3641	Kanred C. I. 5146	Kota C. I. 5878	Arnautka C. I. 4072	Mindum C. I. 5296	Speltz Marz C. I. 6236	Kubanka C. I. 2094	Acme C. I. 5284	Einkorn C. I. 2433	Vernal C. I. 3686	Khapli C. I. 4013
6	4	2+	0;	2+	4—	1+	1+	0;	3+	3+	0;	1+
14	4	2+	2—	2+	4—	4—	4—	4—	4—	3+	1	0;
21	4	4	0	3+	4—	4—	4—	4—	3+	1—	0;	1—
29	4	4—	0	3	x	x	x	x	x	3	0;	0;
3	4	4—	4—	3	0;	0;	0;	0;	3	3—	0;	0;
10	4	2—	4—	2+	4—	3+	3+	3+	3+	3	0;	0;
12	4	4	4—	3	4—	0;	0;	0;	4—	3	0;	0;
18	4	4—	4—	3	0;	0;	0;	3	3+	3	0;	0;
25	4	4—	4—	3	0;	3+	1	3+	4—	3	0;	0;
32	4	4—	4—	3	x	x	x	x	x	3—	0;	0;

[1]Explanation of symbols: 4+, very susceptible; 4 and 4—, susceptible; 3 and 3+, moderately susceptible; 3—, slightly susceptible; 1 and 2, resistant; 0, nonsusceptible; ;, hypersensitive flecks; x, heterogeneous infection. (See Fig. 1.)

On the final recheck p. f. 12 was found to react at variance with the usual reading on some plants of two of the differential hosts; p. f. 25 reacted differently to Mindum and had a tendency to produce a heterogeneous infection on Kubanka; p. f. 29 produced a few pustules on 2 out of the 30 Kanred plants infected; and p. f. 32 did not produce as outstanding a heterogeneous infection on some plants of the differential hosts as it did at the beginning of the experiment. On the whole it can be stated that the 10 physiologic forms were pure at the beginning of the experiment but a few stray spores of other forms were found in some few of the physiologic forms in the final check upon the differential hosts.

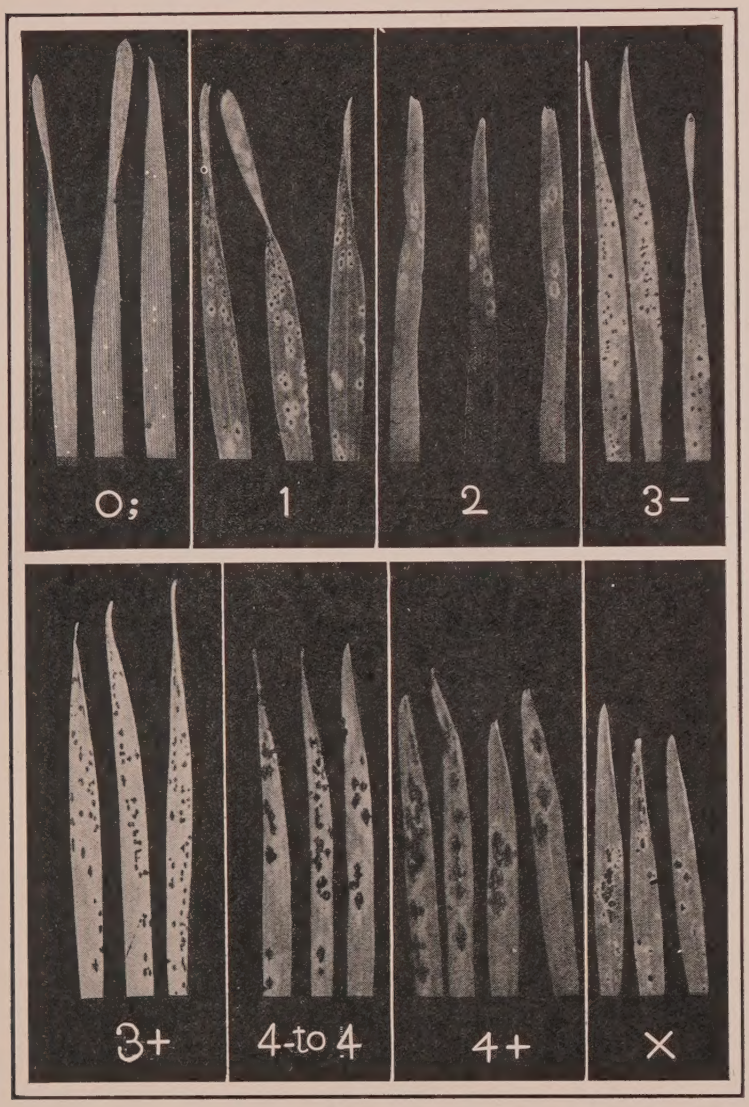

FIG. 1.— Types of infections produced by the physiologic forms of *Puccinia graminis tritici* on the various differential hosts of Triticum spp. The type of infection is indicated by the following symbols: 0;, nonsusceptible; 1, very resistant; 2, resistant; 3– to 3+, slightly susceptible; 4– to 4, susceptible; 4+, very susceptible; and X, indeterminate, as a rule plants that produce this type can be classed as susceptible.

EXPERIMENTAL METHODS

Each strain or variety was represented by a pot containing 6 seedlings which were inoculated by hand in the usual manner when 7 days old. The inoculated seedlings were incubated for 48 hours in a tank large enough to hold the entire lot. A temperature of approximately 23° C. and a saturated atmosphere were maintained in the incubation chamber, conditions which are favorable for infection.

After incubation the plants were trimmed to one leaf and placed on the open bench of a greenhouse held at a temperature of about 25° C. Two weeks after inoculation, a careful reading of the percentage, amount, and type of infection was made.

Care was taken to eliminate sources of systematic errors in these tests including place effects in the greenhouse and the personal element by reading according to fixed standards and without regard to the strain numbers. The various types of infection are illustrated in Fig. 1.

If 50 per cent of the plants of each strain became infected no further tests were made. However, if less than 50 per cent of the plants were infected an additional set of 6 plants were tested. Thus, where either mere flecks or no infection is reported, a total of 12 plants were inoculated the first year. The second year, 3 tests with a total of 18 plants were made, so that in Table 3 where flecks (Fig. 1, Type 0;) or no infection is reported, the results are based in many instances on a total of 30 plants inoculated in 5 separate tests.

Of the 578 Crimean strains, all were tested during the winter of 1924-25, while the number was reduced to include 80 of the most resistant and 20 of the most susceptible ones in the winter of 1925-26. The miscellaneous collection of 43 varieties and strains was tested during both seasons. In addition, 15 replicate tests were made of Kanred during the winter of 1925-26 to serve as a check upon the reliability of the results in general. All of the wheat was infected with 10 physiologic forms in 1924-25 and with 7 forms in 1925-26.

RESULTS

Crimean C. I. 1435 selections:—The 578 Crimean selections are grouped in Table 3 according to their reaction to the 10 physiologic forms of *Puccinia graminis tritici.* The number of strains giving each specific combination of reactions is indicated. While there are many minor variations, it ap-

TABLE 3.—*Comparative reactions*[1] *of Crimean strains to physiologic forms of Puccinia graminis tritici*

Number of strains giving identical reactions	Physiologic forms									
	6	14	21	29	3	10	12	18	25	32
16	S+	S+	S+	S+	S+	S+	S+	S+	S+	S+
5	S+	S+	S+	S+	S+	S+	S+	S+	S+	S+
5	S+	S+	S	S+	S+	S+	S+	S+	S+	S+
2	S+	S+	S+	S+	S	S+	S+	S+	S+	S+
6	S+	S+	S+	S+	S+	S+	S	S+	S+	S+
3	S+	S+	S+	S+	S+	S+	S+	S	S+	S+
1	S	S	S+	S+	S+	S+	S+	S+	S+	S+
1	S	S+	S+	S+	S+	S	S+	S+	S+	S+
6	S+	S	S+	S+	S+	S+	S	S+	S+	S+
1	S+	S	S	S+	S+	S+	S+	S+	S+	S+
1	S+	S	S+	S+	S+	S+	S+	S+	S+	S
4	S+	S+	S	S+	S+	S+	S	S+	S+	S+
4	S+	S+	S	S+	S+	S+	S+	S	S+	S+
1	S+	S+	S	S+	S+	S+	S+	S	S+	S
1	S+	S+	S+	S+	S	S+	S	S+	S+	S+
4	S+	S+	S+	S+	S+	S+	S	S	S+	S+
1	S+	S+	S+	S+	S+	S+	S	S+	S+	S
2	S+	S+	S+	S+	S+	S+	S	S+	S+	S+
1	S	S	S	S+	S+	S+	S+	S+	S+	S+
1	S	S+	S+	S+	S+	S+	S	S+	S+	S+
1	S+	S	S	S+	S	S+	S+	S+	S+	S+
2	S+	S	S	S+	S+	S+	S	S+	S+	S+
2	S+	S	S	S+	S+	S+	S+	S+	S+	S+
2	S+	S	S+	S+	S	S+	S	S+	S+	S+
1	S+	S	S+	S+	S+	S	S+	S+	S+	S+
4	S+	S	S+	S+	S+	S+	S	S	S+	S+
1	S+	S	S+	S+	S+	S+	S	S+	S	S+
1	S+	S	S+	S+	S+	S+	S+	S	S+	S+
1	S+	S+	S	S+	S	S+	S	S	S	S+
1	S+	S	S	S+	S+	S	S+	S+	S	S+
1	S+	S+	S	S+	S+	S+	S	S+	S	S+
1	S+	S+	S	S+	S+	S+	S+	S	S+	S+
1	S+	S+	S	S	S+	S+	S	S	S+	S+
1	S+	S	S	S+	S+	S+	S+	S	S	S+
1	S+	S	S+	S+	S+	S+	S	S+	S+

TABLE 3 (Continued).—*Comparative reactions*[1] *of Crimean strains to physiologic forms of Puccinia graminis tritici*

Number of strains giving identical reactions	Physiologic forms									
	6	14	21	29	3	10	12	18	25	32
1	0	S	S	S+	S	S+	S	S	S	S+
1	S+	S	0	S+	S+	S+	S	S	S	S
1	S+	0	0	S+	S	S	S	S+	S	S
1	S	S	S	S+	S	S	S	S	S	S
9	S	S	S	S	S	S	S	S	S	S
9	S	S—	S	S	S	S	S	S	S	S
2	S	R—	S	S	S	S	S	S	S	S
1	S	S	S	S	S	S	S	S—	S	S
1	S—	R—	S	S	S	S	S	S	S	S
3	S	S—	S—	S	S	S	S	S	S	S
1	S	S—	S	S—	S	S	S	S	S	S
2	S	S—	S	S	S	S—	S	S	S	S
1	S	S—	S—	S	S	S	S—	S	S	S
1	S	R—	S—	S	S	S—	S	S	S	S
1	S—	S—	S—	S—	S	S	S	S	S—	S—
1	S	S	S	S—	S	S	S	S—	S	S
1	S—	S—	0	S—	S	S	S	S	S	S
1	S	S—	0	S—	S	S	S—	S	S	S
3	0	S	S	S	S	S	S	S	S	S
2	S	0	S	S	S	S	S	S	S	S
1	S	0	S	S	S	S	S	S—	S	S
4	S	S	0	S	S	S	S	S	S	S
1	S	S—	0	S	S	S	S	S	S	S
3	0	0	S	S	S	S	S	S	S	S
3	0	S	0	S	S	S	S	S	S	S
1	0	S	0	S	S	S—	S	S	S	S
1	0	S	S—	0	S	S	S	S	S	S
13	S	0	0	S	S	S	S	S	S	S
4	S	0	0	S	S	S—	S	S	S	S
1	S	0	S	0	S	S	S	S	S	S
1	S—	0	S	0	S	S	S	S	S	S
1	S	0	S—	0	S	S	S	S	S	S
1	S	0	S	0	S	S	S	S—	S	S
4	S	S	0	0	S	S	S	S	S	S
1	S	S—	0	0	S	S	S	S	S	S
1	S—	S—	0	0	S	S	S	S	S	S
41	0	0	0	S	S	S	S	S	S	S
6	0	0	0	S—	S	S	S	S	S	S
1	0	0	0	S	S—	S	S	S	S	S
1	0	0	0	S	0	S	S	S—	S	S
6	0	0	0	S	S	S—	S	S	S	S
1	0	0	0	S	S	S—	S—	S	S	S
4	0	0	S	0	S	S	S	S	S	S
1	0	0	S—	0	S	S	S	S	S	S
1	0	0	S	0	S	S	S	S	S—	S
9	0	S	0	0	S	S	S	S	S	S
2	0	S—	0	0	S	S	S	S	S	S
1	0	S	0	0	S—	S	S	S	S	S
1	0	S	0	0	S	S—	S	S	S	S
1	0	S—	0	0	S—	S	S	S	S	S
1	0	S—	0	0	S—	S—	S	S	S	S
1	0	R—	0	0	S	S	S	S	S	S
46	S	0	0	0	S	S	S	S	S	S
2	S—	0	0	0	S	S	S	S	S	S
2	S	0	0	0	S	S—	S	S	S	S
1	S—	0	0	0	S	S	0	S	S	S
1	S	0	0	0	S	S	S	S—	S	S
1	S	0	0	0	S	S	S	S	S—	S
1	S—	0	0	0	S	S	S	S	S	S
1	S	0	S	0	S	S	S	S	0	S

[1]Explanation of symbols: S+, very susceptible; S, susceptible; S—, slightly susceptible; R—, resistant; 0, nonsusceptible, with or without hypersensitive flecks. (See Fig. 1.)

TABLE 3 (Concluded).—*Comparative reactions*[1] *of Crimean strains to physiologic forms of Puccinia graminis tritici*

Number of strains giving identical reactions	Physiologic forms									
	6	14	21	29	3	10	12	18	25	32
202	0	0	0	0	S	S	S	S	S	S
3	0	0	0	0	S—	S	S	S	S	S
23	0	0	0	0	S	S—	S	S	S	S
2	0	0	0	0	S	S	S—	S	S	S
2	0	0	0	0	S	S	S	S—	S	S
1	0	0	0	0	S	S	S	S	S—	S
1	0	0	0	0	S—	S	S—	S	S	S
1	0	0	0	S	S	S	S	S	0	S
1	0	0	0	0	S	S	0	S	S	S
1	0	0	0	0	S	S	S	0	S	S
1	S—	S	S—	S—	S—	S—	S	S—	S—	S
1	S	S—	S—	S—	S—	S—	S—	S—	S	S—
1	S—	S	S—	S—	S—	S	S—	S—	S—	S—
1	S	S—	S—	S—	S—	S—	S—	S—	S—	S—
1	S—	S	S—	S—	S—	S—	S—	S—	S—	S—
1	S—	S—	S—	S—	S—	S—	S—	S—	S	S—
1	R—	S—	S—	S—	S—	S	S—	S—	S—	S—
1	S—	R—	S—	S—	S—	S—	S—	S—	S	S—
3	S—	S—	S—	S—	S—	S—	S—	S—	S—	S—
1	R—	R—	S—	S—	S—	S—	S—	S—	S—	S—
1	0	0	S—	0	S—	S—	S	S—	S—	S—

[1]Explanation of symbols: S+, very susceptible; S, susceptible; S—, slightly susceptible; R—, resistant; 0, nonsusceptible, with or without hypersensitive flecks. (See Fig. 1.)

pears that these combinations may be classed in 4 general groups: (1) Those that were very susceptible to all the rust forms tested, comprising approximately 110 strains. All of these developed pustules thruout of rather extreme types as illustrated by Fig. 1, Type 4 to 4+. (2) A second group of about 237 strains gave reactions essentially identical with those of Kanred which had been selected from the same variety, being highly resistant (Fig. 1, Type 0;, 1, and 2) to p. f. 6, 14, 21, and 29, and decidedly susceptible (Fig. 1, Type 4– to to 4+) to p. f. 3, 10, 12, 18, 25, and 32. (3) A small group of 13 strains is of especial interest in that they were slightly susceptible to all or most of the rust forms developing, in the main, relatively small pustules as shown in Fig. 1, Type 3– to 3+). It is thought that this type of reaction is especially attractive from the standpoint of selecting resistant strains. They differ from those strains reacting similarly to Kanred in that they show some resistance to all or most of the 10 physiologic forms, rather than being very resistant to 4 forms and susceptible to the remaining six. (4) The balance of the selections, 218 in number fell miscellaneously

between the first two groups, and varied in their differential reactions . These, as well as group 1, would appear to offer little promise from the standpoint of rust resistance.

The data of Table 3 are briefly summarized in Table 4 to show the number of strains giving each type of reaction with each of the physiologic forms, without respect to the various combinations in which they occur. When assembled in this manner it is again shown that the strains fall largely into the two primary groups — a susceptible group and a partially resistant group that behave like Kanred. A few strains of intermediate resistance fall under each rust form.

TABLE 4.—*A summary of the comparative reactions of 578 Crimean strains showing the number giving each type of infection with each of 10 physiologic forms of Puccinia graminis tritici*

Relative susceptibility[1]	Physiologic forms									
	6	14	21	29	3	10	12	18	25	32
S+	104	62	69	112	91	100	54	80	98	97
S	127	90	87	118	465	425	505	476	472	468
S—	17	36	22	23	21	53	17	21	6	13
R—	2	7	0	0	0	0	0	0	0	0
O	328	383	400	325	1	0	2	1	2	0

[1]For an explanation of the symbols see Table 3 and Figure 1.

Miscellaneous Varieties and Turkey Strains:—It will be noted in Table 5 that of the 43 varieties tested, five, including (1) Kanred, (2) a long-beak mass-selection of Kanred, (3) Kansas 2414, (4) Kansas 2415, and (5) Tenmarq, give the Kanred reactions, which may probably be accounted for by the fact that they are all related to Kanred. All of the other varieties and selections are relatively more susceptible, and most of them decidedly so.

Reliability of Results:—In order to have a measure of the accuracy of the results, a series of checks was run in 1925, which consisted of planting every eleventh pot thruout the entire collection to Kanred and treating these as individual strains. Thus we have 15 duplicate Kanred checks whose reactions are reported individually for each physiologic form

TABLE 5.—*Comparative reactions of miscellaneous wheat varieties and strains to 10 physiologic forms of Puccinia graminis tritici*

Variety	Physiologic forms									
	6	14	21	29	3	10	12	18	25	32
Turkey (Nebr.)	*S	S—	S	S	S	S	S	S	S	S
Turkey Nebraska 312	R—	R—	S—	S—	S—	R—	S—	S—	S—	S—
Turkey Nebraska 60	*S—	R—	S	S	S	S	S	S	S	S
Turkey Nebraska 10	S+	S—	S	*S	S	S	S	S	S	S
Turkey Nebraska 11	S	S	S	S	S	S	S	S	S	S
Turkey Nebraska 6	S	S	S	S	S	S	S	S	S	S
Turkey Nebraska 30	*S	S—	S	S	S	S	S	S	S	S
Turkey Nebraska 47	S	S—	S	S	S	S	S	S	S	S
Turkey Nebraska 59	S	S—	S	S	S	S	S	S	S	S
Turkey South Dakota 114	R—	R—	S	S	S	S	S	S—	S	S—
Turkey C. I. 1571	*S	*S	S	S	S	S	S—	S—	S	S—
Turkey (Ohio)	*S	S	S+	S	S	S+	S	S	S	S
Illinois No. 10-110	*S	S—	S	S	S	*S	S	S	S	S
Kharkof C. I. 1442	S	S—	S	S	S	S	S	S	S	S
Karmont	S	S—	S	S	S	S	S	S	S	S
Malakof	S	S	S	S	S	S	S	S	S	S
Minturki	S—	S—	S	S	S	S	S	S—	S	S
Minard	*S	*S	S	S	S	*S	S	S	S	S—
Iowa 404	*S	R—	S	S	S	*S	S	S	S	S
Iobred	*S	*S	S	S—	S—	S—	S—	*S—	*S	S—
Montana 36	S	*S	S	S	S	S	S	S	S	S
Baeska	*S	R—	S	S	S—	S—	S	S	S	S
Michikof	S	S—	S	S	S	S—	S	S	S	S
Sherman	S	S	S	S	S	S	S	S	S	S
Red Hussar	S	S	S	S	S	S	S	S	S	S
Beloglina	S	S	S	S	S	S	S	S	S	S
Berkley Rock	S+	S+	S+	S+	S+	S+	S+	S+	S+	S+
Ridit	S—	S—	S	S	S	S—	S	S	S	S
Blackhull	*S	*S	S	S	S	S	S	S—	S—	S
Nebraska 28	S	S	S	S	S	S	S	S	S	S
Seward County, Nebr.†	*S	S—	S	S—	S—	S—	S	*S	S	S
"Buffalo", Buffalo Co., Nebr.†	*S	R—	S	S	S—	S—	S	S	S	S
"Manifold", Clay Co., Nebr.†	S	S	S	*S	S	S	S	S	S	S
"Bulgarian", Polk Co., Nebr.†	*S	*S	S	*S—	S	S—	S—	S	S	S
Black Sea†	S	*S	S	S	S	S	S	S	S	S
CanadaBlueStem,YorkCo.,Nebr.†	*S	*S	S—	S	S	S	S	S—	S	S
Crimean C. I. 1435	0	*S—	S	S	S	S	S	S	S	S
Kanred	0	0	0	0	S	S	S	S	S	S
Kanred, Nebr. Long beak selection	0	0	0	0	S	S	S	S	S	S
Kansas 2414	0	0	0	0	S	S	S	S	S	S
Kansas 2415	0	0	0	0	S	S	S	S	S	S
Kanmarq	S	S	S	S	S	S	S	S	S	S
Tenmarq	0	0	0	0	S	S	S	S	S	S

†These are unidentified varieties of special local farm interest.

*Mixture of plants yielding different types of infection, but in no instances was a heterogeneous infection found on any one leaf.

For explanation of symbols see Table 3.

TABLE 6.—*Reaction of 15 duplicate Kanred[1] checks to 7 physiologic forms of Puccinia graminis tritici [odd numbered columns show the number of plants inoculated (denominator) and the number subsequently infected (numerator)]. The type of infection[2] is shown in the even numbered columns.*

Accession number	Physiologic forms													
	21		29		3		10		18		25		32	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0/18		0/18		5/6	4—	7/18	4—	3/6	3+	1/18	4	4/6	4—
12	0/18		0/18		4/6	4—	6/12	4	2/6	4—	3/6	4—	6/6	4—
23	0/18		1/18	4	5/6	4—	2/12	4—	3/6	4	5/6	4—	5/6	4
34	0/18		1/18	4	12/18	4—	2/12	3+	5/6	4—	5/6	4—	5/6	4
45	0/18		0/18		6/6	4	4/12	4—	3/6	4—	3/5	4—	4/6	4—
56	0/18		1/18	4	6/6	4	2/12	4—	5/6	4—	3/6	4	4/6	4
67	2/18	3+	0/18		6/6	4	2/12	4	5/6	4—	4/6	4	4/6	4—
78	1/18	4	0/18		5/6	4—	3/12	4—	4/6	4	3/6	4	5/6	4
89	0/18		2/18	4	3/6	4—	2/12	4	3/6	4—	6/6	4—	5/6	4
100	0/18		0/18		6/18	4	2/12	4—	6/6	4	5/6	4	5/6	4
111	0/18		0/18		6/6	4	5/12	4—	6/6	4—	4/18	4	6/6	4
122	0/18		0/18		5/6	4—	2/12	4—	5/6	4—	4/6	4—	4/6	4
133	0/18		1/18	3++	6/6	4	5/12	4—	5/6	4	0/18		5/6	4
144	1/18	3—	0/18		5/6	4—	2/12	4—	5/6	4	3/6	4	3/6	4—
155	0/18		0/18		4/6	4—	4/12	4—	6/6	4	3/18	4—	4/6	4

[1]The wheat used was a special "long beak" mass-selection of Kanred.
[2]See Table 2 and Fig. 1.

in Table 6. Seven of the checks gave the correct Kanred results thruout. In 4 checks 6 per cent and in one check 12 per cent of the plants gave the wrong Kanred reading for p. f. 29. In 2 checks 6 per cent and in one check 12 per cent of the plants gave the wrong Kanred results for p. f. 21. Of the entire number of 105 reactions with Kanred, 97 were as expected and 8 showed slight contamination. These results indicate the likelihood of some error in the comparisons of varieties and Crimean strains but that in the main the reactions obtained and the principle indicated may be relied upon.

SUMMARY

The data indicate that there may be decided variation in the differential reaction of wheat strains within a commercial variety to various physiologic forms of *Puccinia graminis tritici*.

The 578 strains selected from Crimean C. I. 1435 and under observation in these tests, contain two groups of strains which offer decided promise for further testing in the field for comparative performance. The strains of one of these groups react like Kanred, while those of the other small group are moderately resistant to all 10 physiologic rust forms. All the other selections are more susceptible than Kanred.

In a miscellaneous group of varieties and Turkey strains, none proved more resistant than Kanred. This variety and 4 related strains which react alike surpass all the others in this regard, tho more than 200 new selections from Crimean C. I. 1435 give the same reaction as Kanred to the 10 physiologic forms.

For a detailed account of wheat investigations and stem rust studies conducted at the Nebraska Station the readers are referred to Research Bulletins 22, 25, 28, 31, 34, and 35, and Bulletin 201.